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Sharp Reductions in Abundance of Fishes and Benthic Macroinvertebrates in the Gulf of Mexico Off Texas Associated with Hypoxia

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SHARP REDUCTIONS IN ABUNDANCE OF FISHES AND BENTHIC MACROINVERTEBRATES IN THE GULF OF MEXICO OFF TEXAS ASSOCIATED WITH HYPOXIA[1]

Natural depletion of dissolved oxygen (D.O.) to hypoxic (<2.0 mg/l) or anoxic levels in bottom waters of the continental shelf of the northwestern Gulf of Mexico (Gulf) has been recognized since the mid-1930's (Conseil Perm. International pour l'exploration de la mer, 1936). Subsequent, but primarily unpublished, studies suggest this is a recurrent hydrographic feature off Louisiana (Farrell, 1974; Harris *et al.* 1976, Brent *et al.* 1979, Fotheringham and Weissberg, 1979; Bedinger *et al.*, 1980; Reitsema, 1980), and possibly off Texas (Harper and McKinney, 1980; Slowey, 1980; Harper *et al.,* 1981).

Little has been published about the effects of natural hypoxia on fishes, shrimps and other macroinvertebrates in the northwestern Gulf despite its apparent frequency and the valuable fisheries in that region. Ragan *et al.* (1976), and Fotheringham and Weissberg (1979) reported sharp declines in the abundance of fishes, anthozoans, polychaetes, bivalves, and crustaceans under hypoxic and/or anoxic conditions. Data on reduced abundance of benthic infauna during hypoxia have been presented by Harper *et al.* (1981) but no data have been published for fishes and shrimps (*Penaeus* spp.).

This paper documents sharply reduced abundance and the elimination of both fishes and shrimps coincident with hypoxia off Texas and presents general observations about decreases in common benthic macroinvertebrates.

MATERIALS AND METHODS

A total of 2,880 trawl tows was made on 71 monthly or twice monthly cruises from October 1977 through August 1981 along a transect from 5-47 m in the Gulf off Freeport, Texas (Figure 1). Cruises were made by day prior to December 1978. Thereafter, a night cruise and a day cruise normally were made each month. Collections were made from a commercial shrimp trawler using twin 10.4 m shrimp trawls with tickler chains and 4.4 cm stretch mesh in the cod ends at stations in depths of 5, 9, 13, 16, 18, 22, 24, 27, 36, and 47 m. Two tows of ten minutes duration (bottom time) were usually made at each depth. However, we emphasize that 8-12 tows were made at the 16 m isobath and 24 tows were usually made at the 22 m isobath. This extensive trawling was conducted within an area where hypoxia occurred (Harper *et al.,* 1981).

All fishes and shrimps were identified and enumerated by species; the other more abundant macroinvertebrates

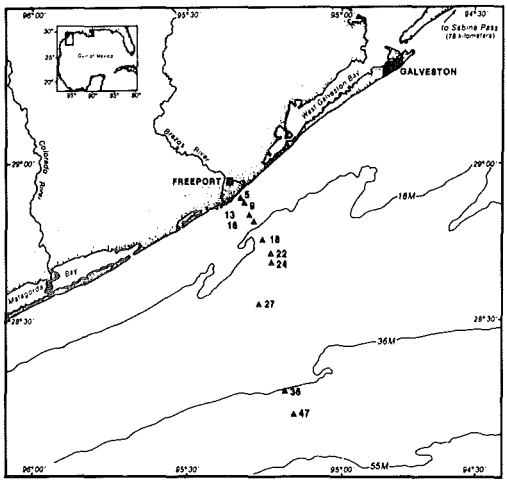

Figure 1. Location and depths (meters) of trawl stations off Freeport, Texas.

[1]*Technical article 17991 from the Texas Agricultural Experiment Station.*

were simply identified.

Bottom water samples were collected with a Kemmerer bottle at each depth between the 5-36 m isobaths from August 1979-1981 to determine dissolved oxygen using the Alsterberg (azide) modification of the Winkler Method (American Public Health Association, 1976). However, we collected no D.O. data concurrent with trawling prior to August 1979; D.O. values presented for May, June and July 1979 were obtained from other cited researchers working in our study area.

RESULTS AND DISCUSSION

Fishes and shrimps normally are abundant between the 5-47 m isobaths off Freeport when D.O. levels are high during the summer. Mean catch per tow (C/f) of fishes and shrimps generally was high throughout this bathymetric range from May through August or September in 1980 and 1981 (Figures 2 & 3) and in May, early June, August and September 1979 (Figure 4, panels A, B, F & G) when D.O. levels were above 2.0 mg/l. Similarly, C/f generally was high from May through September 1979 between the 5-9 m isobaths in the white shrimp (*Penaeus setiferus*) community and between the 24-47 m isobaths in the brown shrimp (*P. aztecus*) community (Figure 4) delineated by Hildebrand (1954) and Chittenden and McEachran (1976).

The primary exceptions to these generalizations are:

1) the generally low catches of shrimps during day cruises between the 18-47 m isobaths. This is normal and reflects the fact that

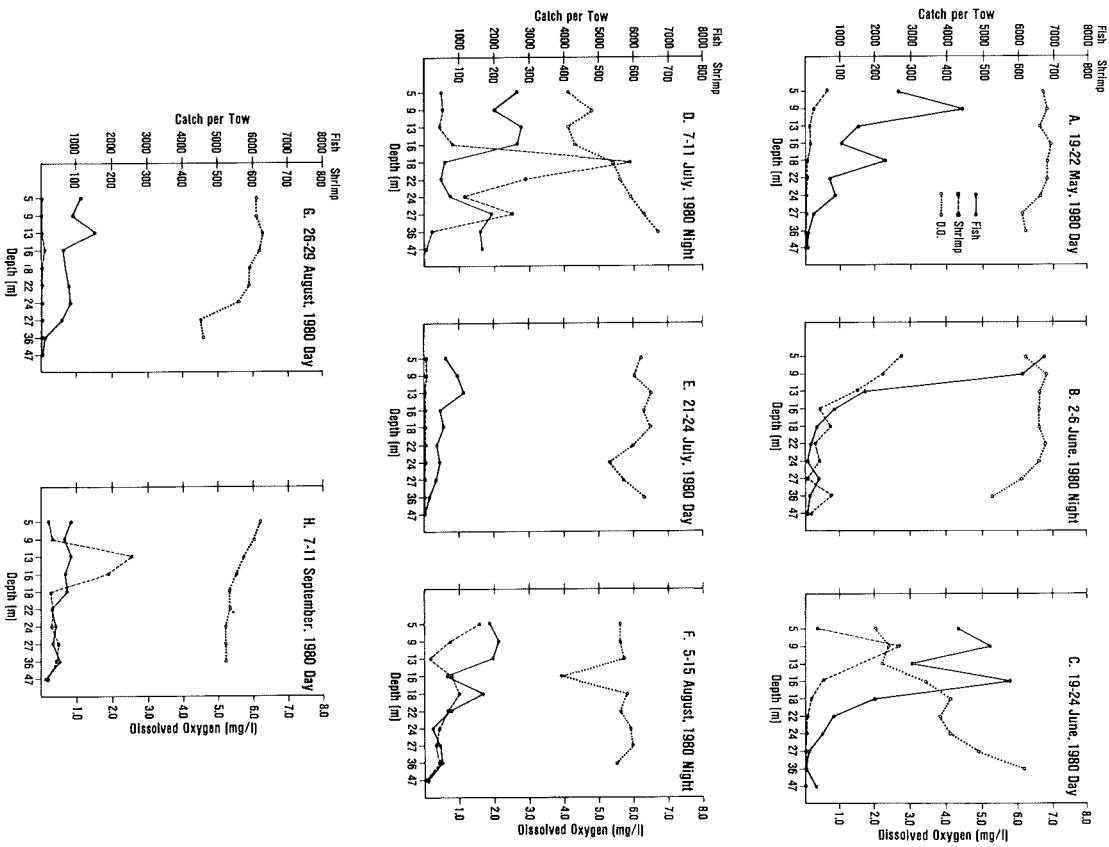

Figure 2. Mean catch per tow of shrimps (*Penaeus* spp.) and fishes in relation to D.O. and station depths, May-September 1980.

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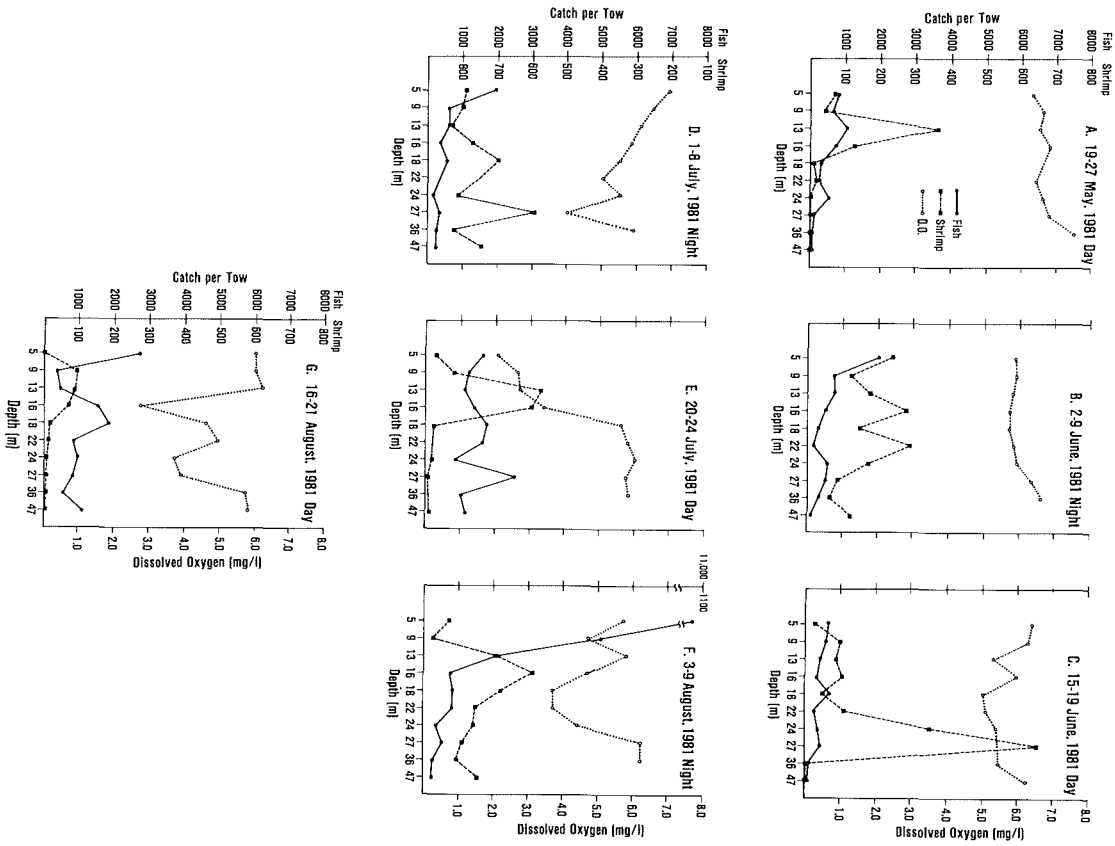

Figure 3. Mean catch per tow of shrimps (*Penaeus* spp.) and fishes in relation to D.O. and station depths, May-August 1981.

greater catches of most *Penaeus* spp. are made at night (Williams, 1955; Perez-Farfante, 1969; Wickham and Minkler, 1975). *Penaeus aztecus* predominates in this bathymetric range in our study area, but they are rarely captured there during the day even when night catches in the same month are large (Chittenden *et al.*, 1980; 1982).

2) the often relatively low catches of fishes and shrimps between the 18-47 m isobaths. This is normal and reflects decreased nekton abundance off Freeport with increasing depth and distance from shore; catches between the 5-9 m isobaths often are much greater than those in deeper water (Chittenden *et al.*1980; 1982).

Unusually low abundance or the total elimination of both fishes, shrimps, and other macroinvertebrates, occurred in bottom waters between the 13-24 m isobaths during June and July 1979 associated with hypoxic conditions. Catches increased dramatically at these depths in late August 1979 when D.O. levels recovered. Data from four cruises document these changes:

1) Unusually low abundance was first evident in the field between 21-24 June 1979 when hardly any fishes or shrimps were captured in ten tows at 13 and 16 m (Figure 4, panel C). A distinct decline was also observed in catches of other typically abundant macroinvertebrates including penaeid shrimps *Trachypenaeus* spp., *Sicyonia brevirostris, S. dorsalis* and

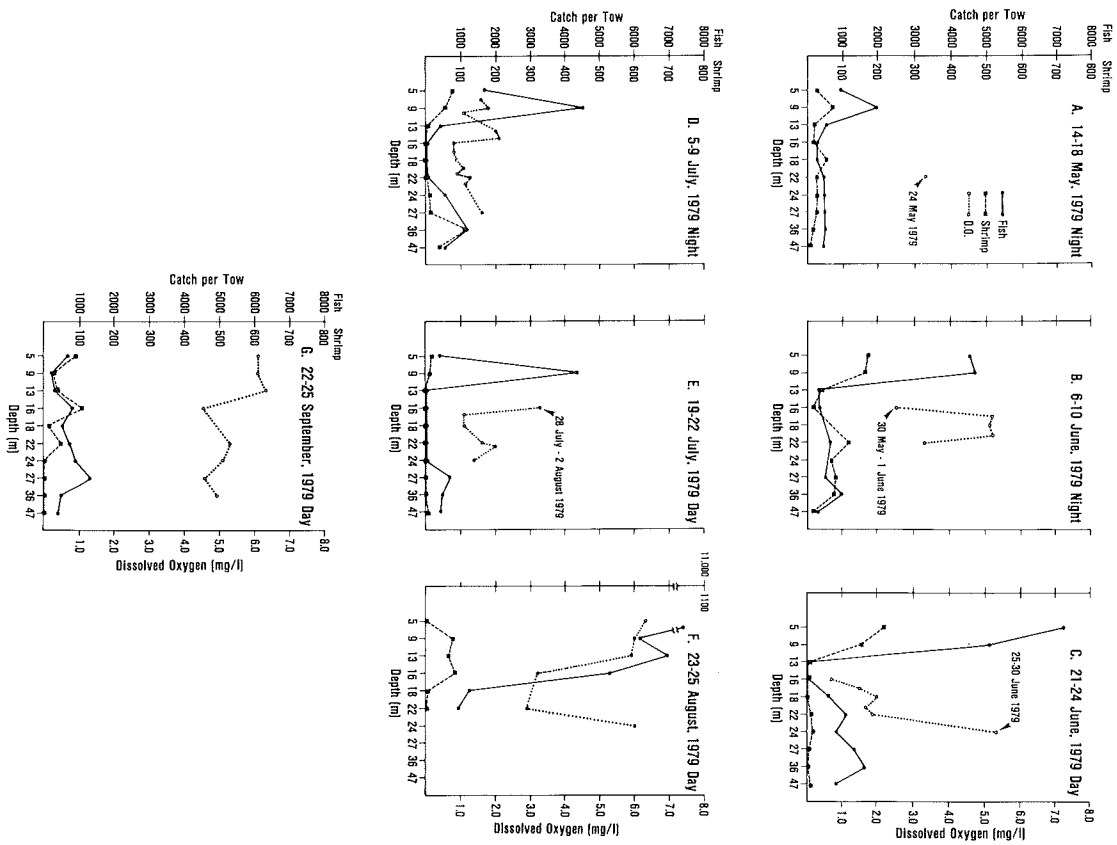

Figure 4. Mean catch per tow of shrimps (*Penaeus* spp.) and fishes in relation to D.O. and station depths, May-September 1979. Collection dates are indicated when D.O. measurements were not taken concurrent with trawling.

Xiphopenaeus kroyeri; brachyuran crabs, *Callinectes sapidus, C. similis, Libinia dubia, L. emarginata, Calappa flammea, C. sulcata, Hepatus epheliticus, Portunus* spp., *P. spinicarpus*; mantis shrimp, *Squilla empusa,* and squid, *Lolliguncula brevis.* Harper *et al.* (1981) and Slowey (1980) found hypoxic bottom water (0.7-2.0 mg/l) at 16-22 m along our station transect on 25-30 June 1979 which is only a few days after we observed sharply reduced nekton abundance.

2) The area that exhibited unusually low C/f broadened by 5-9 July 1979 to include the 13-22 m isobaths where few or no fishes, shrimps (Figure 4, panel D) or macroinvertebrates were captured in 28 tows. Harper *et al.* (1981) recorded bottom D.O. levels of 0.8-2.1 mg/l between 9-33 m during our cruise.
3) We captured no fishes or shrimps in 27 tows between the 13-24 m isobaths on 19-22 July 1979 (Figure 4, panel E); our entire catch included only dead and decaying brachyuran and anomuran crabs, mantis shrimp and the anthozoan *Renilla reniformis.* No D.O. data exists for this period but Harper *et al.* (1981) and Slowey (1980) found hypoxic bottom water (1.6-3.3 mg/l) still present at 18-22 m the following week (28 July-2 August 1979).
4) Fish and shrimp abundance in-

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creased tremendously between the 13-22 m isobaths on 23-25 August 1979 (Figure 4, panel F). Abundance of macroinvertebrates was also much greater than July and no dead or decaying organisms were observed in the catch. Increased abundance was most conspicuous between the 13 and 16 m isobaths where sharp declines in abundance were first noted in late June. The resurgence in nekton abundance coincided with high bottom D.O. levels (2.9-6.0 mg/l) that we measured between the 13-24 m isobaths.

The sharp reduction and elimination of nekton from bottom waters between the 13-24 m isobaths off Freeport during late June and July 1979 was probably due to natural hypoxia. Although we did not collect D.O. data concurrent with our trawling, Harper *et al.* (1981) and Slowey (1980) document the presence of hypoxic bottom water in our study area at about the same times we observed greatly reduced — or absent — nekton. In contrast, nekton C/f: 1) was consistently high and seemed normal under non-hypoxic conditions during these same months in 1980 and 1981 and just prior to the onset of hypoxia in 1979, 2) was high just inshore and offshore of the hypoxic area in 1979, and 3) increased greatly in late August 1979 between the 13-24 m isobaths just after hypoxic conditions passed.

Reductions in nekton abundance due to hypoxia might be a recurrent phenomenon off Freeport. A similar though less severe decline in nekton C/f occurred in June 1978 between the 9-16 m isobaths. Harper *et al.* (1981) noted decreased diversity and abundance of benthic invertebrates in the same area at the same time. Unfortunately, neither we nor Harper *et al.* have D.O. data to establish hypoxia as the cause on that occasion. Hypoxic conditions also existed between the 7-20 m isobaths during early June 1982 (R. E. Randall, Dept. of Civil Engineering, Ocean and Hydraulic Engineering Div., Texas A&M Univ., College Station, TX 77843, pers. commun.). However, this occurred after we ceased collections in that depth range.

The ecological impact of natural hypoxia on nekton dynamics in the northwestern Gulf is not clear but could be important because a large region may be affected. Our data indicate hypoxic bottom waters greatly reduced nekton abundance in a cross-shelf band of at least 15 km between the 13-24 m isobaths during some periods of summer 1979. Harper and McKinney (1980) estimated that hypoxia in early July 1979 off Texas extended along the coast from Sabine Pass to Matagorda Bay (130 km) and across the shelf from 9-33 m (50 km).

Although hypoxia in the bottom water appears to greatly reduce the abundance of benthic and demersal nekton, it seemingly has little effect on larger pelagic fishes near the surface and might even benefit them. On 19-22 July 1979, when we captured only dead and decaying specimens within the 13-24 m isobaths, we observed many pelagic fishes swimming at the surface including sharks, (*Carcharhinus* spp.), pompano dolphin, (*Coryphaena equisetis*), little tuna, (*Euthynnus alletteratus*), crevalle jack, *Caranx hippos,* and mackerel (*Scomberomorus* spp.). It is not clear whether or not we observed an unusual abundance of larger pelagic fishes on this occasion. However, it is tempting to speculate that these fishes might have been attracted to or were held in the area by an exceptional food opportunity presented during June and July by an unusually vulnerable bottom fauna

distressed by hypoxia.

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LITERATURE CITED

American Public Health Association. 1976. Standard methods for the examination of water and wastewater (fourteenth ed.): 433. Washington, D.C.

Bedinger, C.A., J.W. Cooper, A. Kwok, R.E. Childers, and K.T. Kimball. 1980. Ecological investigations of petroleum production platforms in the central Gulf of Mexico. Volume 1: Pollutant fate and effects studies. Draft final report submitted to the Bureau of Land Management, Contract No. AA551-CT8-17. 149 p.

Brent, C.R., H.P. Williams, W.A. Bergin, J.L. Tyroll, and T.E. Myers. 1979. Organic carbon, inorganic carbon and related compounds in offshore oil production areas of the northern Gulf of Mexico, p. 245-264. In: C.H. Ward, M.E. Bender, and D.J. Reish (eds.), Effects of oil drilling and production in a coastal environment. Rice Univ. Stud. 65(4&5):1-589.

Chittenden, M.E., Jr., and J.D. McEachran. 1976. Composition, ecology and dynamics of demersal fish communities on the northwestern Gulf of Mexico continental shelf, with a similar synopsis for the entire Gulf. Texas A&M Univ. Sea Grant Publ. TAMU-SG-76-208.

_____, J.S. Pavela, and J.L. Ross. 1982. Nekton, p. 4.1-4.155. In: R.W. Hann Jr. and R.E. Randall (eds.), Final report of 18 month postdisposal studies to the Department of Energy, Contract No. DE-FC96-79P010114.

_____, J.L. Ross, and J.S. Pavela. 1980. Nekton, p. 4.1-4.131. In: R.W. Hann Jr. and R.E. Randall (eds.), Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program, Final report of predisposal studies to the Department of Energy, Contract No. DE-FC96-79P010114.

Conseil Perm. International pour l'exploration de la Mer. 1936. Bull. Hydrographique pour l'Anee 1935, 89:101-102.

Farrell, D. 1974. Benthic communities in the vicinity of oil producing wells on the shallow Louisiana continental shelf. Offshore Ecol. Invest., Gulf Univ. Res. Consortium. 52 p.

Fotheringham, N. and G. Weissberg. 1979. Some causes, consequences and potential impacts of oxygen depletion in the northern Gulf of Mexico. Offshore Tech. Conf. Proc. OTC 3611: 2205-2207.

Harper, D.E., Jr., and L.D. McKinney. 1980. Benthos, p. 5.1-5.78. In: R.W. Hann Jr. and R.E. Randall (eds.), Evaluation of brine disposal from the Bryan Mound site of the Strategic

DOI: 10.18785/negs.0602.11

Petroleum Reserve Program, Final report of predisposal studies to the Department of Energy, Contract No. DE-FC96-79P010114.

_____, R.R. Salzer, and R.J. Case. 1981. The occurrence of hypoxic bottom water off the upper Texas coast and its effects of the benthic biota. Contrib. Mar. Sci. 24:53-79. 1981.

Harris, A.H., J.G. Ragan, and J.H. Green. 1976. Oxygen depletion in coastal waters. Sea Grant Sum. Rep. Proj. No. R/BOD-1. 161 p.

Hildebrand, H.H. 1954. A study of the brown shrimp (*Penaeus aztecus* Ives) grounds in the western Gulf of Mexico. Univ. Tex. Publ. Inst. Mar. Sci 3(2):1-366.

Perez-Farfante, I. 1969. Western Atlantic shrimps of the genus *Penaeus.* Fish. Bull. U.S. 67(3):461-590.

Ragan, J.G., A.H. Harris, and J.H. Green. 1976. Temperature, salinity and oxygen measurements of surface and bottom waters of the continental shelf off Louisiana during portions of 1975 and 1976. Nicholls St. Univ. Prof. Pap. Ser. (Biol.) (3):1-9.

Reitsema, L.A. 1980. Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. Vol. 2: Zooplankton. NOAA Tech. Mem. NMFS-SEFC-16. 133 p.

Slowey, J.F. 1980. Water and sediment quality, p. 3.1-3.74. In: R.W. Hann Jr. and R.E. Randall (eds.), Evaluation of brine disposal from the Bryan Mound site of the Strategic Petroleum Reserve Program, Final Report of Predisposal studies to the Department of Energy, Contract No. DE-FC96-79P010114.

Wickham, D.A., and F.C. Minkler. 1975. Laboratory observations on daily patterns of burrowing and locomotor activity of pink shrimp, *Penaeus duorarum* brown shrimp, *P. aztecus* and white shrimp, *P. setiferus.* Contrib. Mar. Sci. 19:21-35.

Williams, A.B. 1955. Substrates as a factor in shrimp distribution. Limnol. Oceanogr. 3(3):283-290.

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